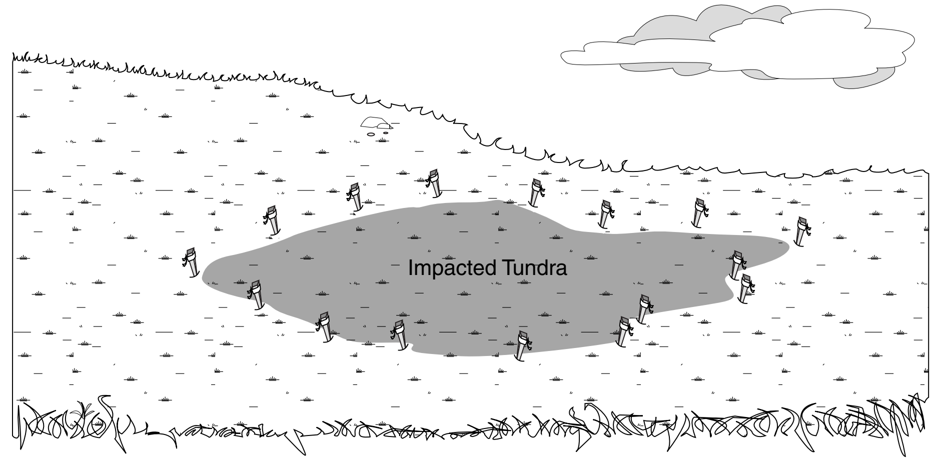

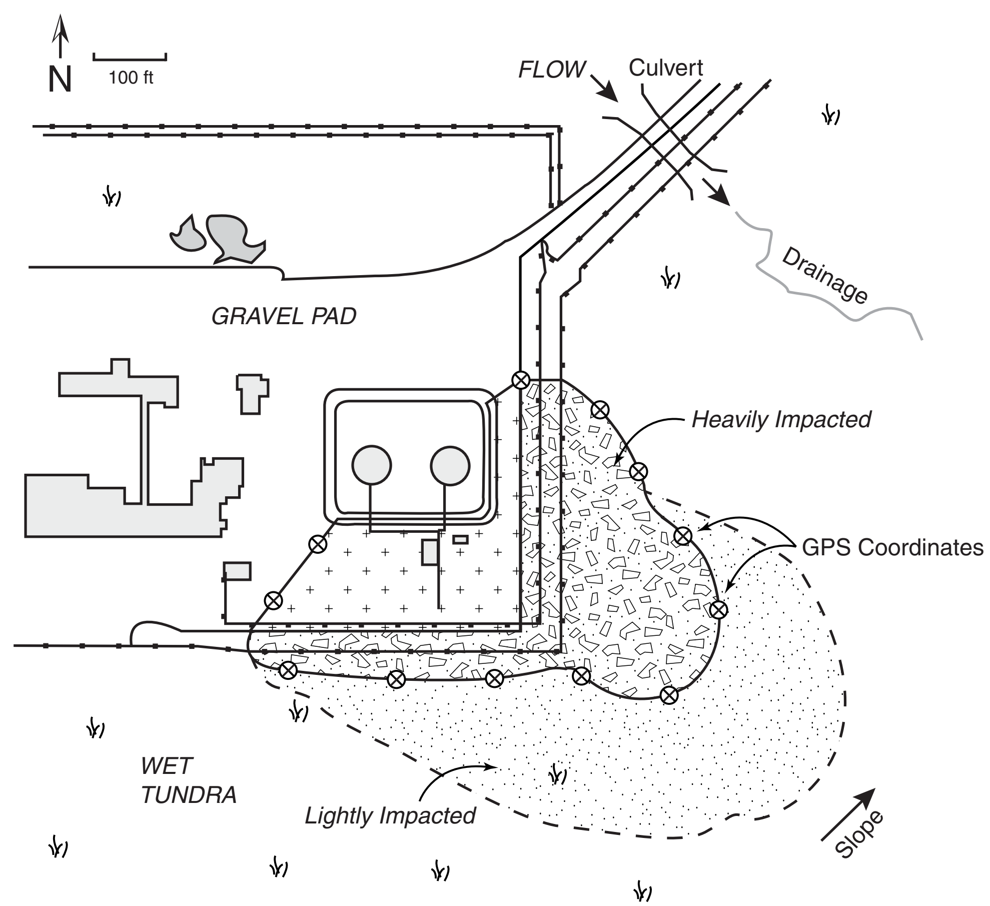

This tactic describes how to mark the spill area so that its boundaries can be located in case subsequent snowfall or windblown snow covers the tundra. This should be done as soon as possible after the spill. The extent of the spill may already have been marked during early response measures. Retrace the boundaries to confirm to earlier delineation.

To delineate large spill areas (>1,000 square feet), two workers walk the perimeter of the spill in opposite directions from a common point and meet on the opposite side of the spill area. The workers look for signs of the spilled substance on the ground, soil or plant discoloration, sheen on standing water or foliage, and dead or damaged vegetation, and place wood laths in the ground every 50 to 100 feet near the edge of the spill. The workers should then retrace each other's routes to confirm the delineation. For smaller spills, one person may perform the delineation. If a hand-held global positioning system (GPS) is available, the GPS coordinates can be marked on the wooden laths and used to generate a scaled map of the site. Aerial photographs may be invaluable for identifying and mapping site features and spill boundaries

A scaled map of the site may be required for planning, monitoring, and reporting purposes. A site map should show the following elements (at a minimum):

- Location of the spill source
- Boundary of the spill-affected area
- Areas of light and heavy concentrations
- Adjacent roads and structures
- Sensitive areas
- Nearby drainages or waterbodies and direction of water movement
- Slope and distinctive topographical features
- Sampling locations (including background samples) — use insets as necessary
- Vegetation study plots, transects, or photoplot locations — use insets as necessary
- North arrow and scale

APPLICABILITY

	APPLICABILITY	COMMENTS
SPILLED SUBSTANCE	Crude oil, fuels, glycol, methanol, Therminol	• Spills of saline or water-soluble substances in wet or moist tundra are difficult to delineate using visual indicators.
TUNDRA TYPE	All	• Spilled substances may be carried by water and spread from the initial spill area in moist and wet tundra. • Spilled substances may flow or be carried by rain or melt water vertically into dry tundra soil, and may not spread horizontally as much as in wet or moist tundra.
SEASON	All	• Delineate the spill area as soon as possible in case subsequent snowfall covers the tundra.

CONSIDERATIONS AND LIMITATIONS

- The area of an uncontained spill of a saline substance will expand with time on all types of tundra as the spill dilutes and spreads.
- The boundaries of spills of saline or water-soluble substances on wet or moist tundra are difficult to delineate visually. These spills tend to dilute and spread rapidly. If salt or other water-soluble compounds are present in high enough concentrations, the vegetation will die or show signs of stress (wilting, discoloration, loss of foliage) in affected areas.
- This tactic has been adapted from Tactics T-1 and T-2 in the *Alaska Clean Seas Technical Manual* (Alaska Clean Seas, 1999, Vol. 1).

EQUIPMENT, MATERIALS, AND PERSONNEL

- Wooden lath stakes (1 or 2 workers) – to mark spill perimeter at 50- to 100-foot intervals
- GPS unit (1 operator) – to provide coordinates for site mapping

Field indicators are standardized, simple, qualitative observations and measurements that can be made periodically at a site to monitor and document treatment effectiveness and to identify trends in tundra recovery (Cater and Jorgenson, 1999). They also provide a context for interpreting chemical analytical data. Field indicators — along with soil sampling and analysis for spilled substances (Tactic AM-3) and vegetation monitoring (Tactic AM-5) — are important components of a baseline site assessment or monitoring program.

Measure and observe field indicators at pre-established sampling points on the site. The number and location of these points should be established by agreement between the responsible party and government agencies. Field sampling points should represent the entire site, with no bias to either heavily or lightly impacted areas; and the number of locations should be directly proportional to the concentration and extent of contamination. A smaller site with heavily concentrated contamination may require a more intensive sampling approach (10 field sampling points per 0.1 acres). For larger sites, spread field sampling points out over a large area to characterize the entire site (1 sample per 0.2 acres). Field indicators should be also be measured in surrounding (background) areas for comparison.

Field sampling points can be established on the semi-permanent sampling grid. The grid can be either rectangular for larger sites or circular for smaller sites, and should include points both in the spill area and in surrounding unaffected areas. Once a grid is established and numbered, sampling locations are set at selected interception nodes (where perpendicular lines intersect) inside the grid. Selection of grid points for field indicator observations and measurements should be systematic or random and not subjective. Ideally, the same measurements and observations should be made at all field sampling points.

Mark the sampling points with stakes and record their locations on a scaled site map (Tactic AM-1) so they can be easily and accurately found in the future. Make subsurface soil observations using a geologist's coring tool (about 1.5-inch-diameter), or if a coring tool is unavailable or soil is gravelly, by digging small "test pits."

Three categories of field indicators may be measured or observed:

- ***Spill Residue:*** Treatment progress is indicated by reductions in visually apparent level of contamination on the soil and vegetation.
- ***Soil Conditions:*** Evaluating infiltration levels will provide information on the capability of a site to revegetate. The root mat, where contamination can do the greatest damage, is 10 to 20 centimeters below ground surface. The amount of contamination in this highly sensitive zone is a good indicator of how contamination might impact successive plant growth. Progress is again indicated by a visually apparent reduction in concentration.
- ***Ecological or Physical Damage:*** Physical damage can potentially have more long-term impact on the tundra than contamination. Monitoring physical damage can help determine the point at which intensive physical treatment should stop. Thermokarst presence or absence should also be monitored. Progress is indicated by regrowth of native plants and re-establishment of drainages and soil contours.

Some Field Indicators for Presence of Spill Residue (Crude Oil or Diesel*)

PARAMETER	MEASUREMENT OR OBSERVATION
Residue thickness on ground or vegetation	• No visible residue • If sheen is present, thickness is 0.0001 millimeters (mm) • If stain is present, thickness is 0.1 mm • If coating can be scraped with an object, thickness is 1 mm • If thickness is >1 mm, measure with ruler
Residue consistency	• No visible residue • Flowing (liquid) residue • Mousse (if crude oil) • Waxy • Hardened or crystalline • Crumbly or Friable • Sheen
Residue expulsion (residuals can be squeezed out of surface organics or soil with foot)	• No expulsion • Sheen on water • Liquid droplets • Pooling on surface • Undetermined
Residue color	• Silver gray sheen • Rainbow sheen • Light orange-brown • Dark brown • Blue black
Cleanup methods	• Note methods used
Treatment tactics	• Note tactics used

*Field indicators for other types of residues must be developed on a case-by-case basis.
Adapted from Cater and Jorgenson, 1999.

Some Field Indicators of Soil Conditions

PARAMETER	MEASUREMENT OR OBSERVATION
Organic layer	• Measure thickness of organic layer • Note any discoloration • Note odor
Mineral soil layer	• Measure depth mineral layer begins • Note any discoloration • Note odor
Mineral soil texture	• Clay (silty clay, silty clay loam) • Loam (silt loam, sandy loam, silt) • Sand (loamy sand, gravelly sand) • Gravel (sandy gravel, silty sandy gravel)
Thaw depth	• Probe for thaw depth
Water depth	• Probe for depth above or below ground surface
Spill infiltration	• Saturation -- spilled substance fills pore spaces in soil • Coating -- noticeable coating on mineral or organic particles, void spaces are evident, or substance does not flow off of particles • Sheen -- sheen shows when soil squeezed but not evident on particles

Adapted from Cater and Jorgenson, 1999.

Some Field Indicators for Physical or Ecological Damage

PARAMETER	MEASUREMENT OR OBSERVATION
Tundra type	• Wet tundra • Moist tundra • Dry tundra • Bare soil
Vegetation cover (Tactic AM-5)	• Cover estimates (0 to 5%, 6 to 25%, 26 to 50%, 51 to 75%, 76 to 95%, 96 to 100%) for shrubs, graminoids, mosses, and bare soil
Vegetation damage	• No apparent damage • Partially crushed (some stems and leaves crushed, but structure mostly intact) • Mostly crushed (stems and leaves recognizable, but mostly laying flat on ground) • Stressed (wilted, dropping leaves, or leaves discolored) • Dead • Roots exposed • 1 to 5 inches of organic layer or soil removed • >5 inches of organic layer or soil removed
Birds and mammals	• Species and number observed at the entire site • Condition (healthy, diseased, dead) • Note whether spill residue visible on animal • Animal dead, probably due to other causes

Adapted from Cater and Jorgenson, 1999.

APPLICABILITY

- *Spilled Substance:* All
- *Tundra Types:* All
- *Season:* Spring, summer, fall

CONSIDERATIONS AND LIMITATIONS

- Avoid placing stakes in locations that interfere with treatment operations.
- Water-soluble spill residues may not be visible on the tundra surface.
- A thawed active layer and absence of snow cover are required for most observations or measurements of field indicators.

EQUIPMENT, MATERIALS, AND PERSONNEL

NOTE: Generally a team of two workers can measure or observe field indicators.

- Ruler or measuring tape – to measure residue, soil layer thicknesses
- Metal probe – to measure depth of thaw, water depth
- Geologist's coring tool – to extract soil from active layer to observe soil horizons
- Shovel – to dig small test pit to observe soil horizons
- Wooden laths or steel "rebar" stakes – to mark areas where field indicators were measured or observed so they can be found during subsequent monitoring events.

Government agencies may require periodic laboratory analysis of soils and water throughout the treatment and rehabilitation process. This tactic describes procedures for sampling and analysis of spilled substances in tundra soil, surface water, and subsurface (active layer) water. The Alaska Department of Environmental Conservation must approve sampling and analysis plans. Occupational Safety and Health Administration regulations require special training for sampling hazardous substances such as crude oil, petroleum products, methane, and glycol.

Selection of Sample Sites

To reinforce a correlation between analytical results and field-indicator observations and measurements, use field indicator sampling points (Tactic AM-2) for analytical sampling locations whenever possible or collect field indicator data at analytical sample locations. Avoid collecting analytical samples from areas previously disturbed by field indicator observations.

Sampling frequency is determined by the monitoring schedule and requirements of agencies. An intensive treatment and monitoring program may require ongoing sampling (weekly to monthly), and other less-intense programs may require monitoring only once a year. Sampling is normally performed when the tundra is thawed.

Preventing Cross-Contamination

Avoid cross-contamination of samples by using proper sample-handling techniques and decontamination practices. Use clean sampling equipment and clean, disposable sampling gloves for each sample. Decontaminate sampling equipment before each sampling event to ensure collection of representative samples and to prevent cross-contamination. Use a laboratory-grade detergent and preferably hot potable water to clean sample equipment. Rinse with tap water followed by multiple rinses with de-ionized water.

Soil Sampling Procedures

A cross-section of tundra would show two distinct layers of soil differentiated by color and texture. The upper horizon consists of a dark organic soil that is often smooth in texture, while the lower horizons are often lighter or gleyed mineral soil with a sandy or silty texture.

Collect samples separately for the upper organic horizon and the lower mineral soil horizon. Stainless steel spoons, disposable sample scoops, shovels, and hand augers may be used to collect surface/near-surface samples. All sampling equipment must be decontaminated before each sampling event.

Surface soil samples must be collected from freshly uncovered soil to minimize the loss of any volatile fractions of analytes. A sample must be transferred directly from the freshly uncovered soil to the laboratory-supplied sample container with the sampling equipment (e.g., disposable sample scoop). If the sample is to be collected in a test pit that has been open for longer than one hour, a minimum of 3 inches of soil should be removed immediately before collection.

Surface Water Sampling Procedures

Surface water may be present at or near field-indicator sampling points (Tactic AM-2), and surface water samples should be collected as close to these points as possible. Collect these samples by gently immersing a clean sample bottle in the surface water. Avoid disturbing sediments in the immediate vicinity of the collection point before sample collection.

Field water- quality measurements may be recorded after sample collection, including:

- Temperature
- pH
- Specific conductance
- Dissolved oxygen

Calibrate the instruments in the field before use.

Active-Layer Water Sampling

Well points may be installed for subsurface sampling. Before sampling, wells should be developed by removing five well volumes (calculated from the volume of water inside the well casing) from the well to remove any water or fluids introduced into the well during installation. Before each sampling event, three well casing volumes should be purged from the well point to ensure a representative sample of subsurface water. Develop and purge well points with a disposable bailer or a peristaltic pump. Collect development and purge water in drums and dispose of it according to applicable regulatory guidelines.

Use a sterile, disposable bailer to collect water samples from well points. Immediately place water into sample containers and preserve as specified by the analytical laboratory.

Laboratory Analysis Plan

The type of substance spilled and the sample media dictate the analysis used. Laboratories will provide sample containers and specify required sample quantities.

Example Sampling and Analysis Parameters

SPILLED SUBSTANCES	ANALYSIS	MATRIX	EPA/ADEC METHOD	CONTAINERS (will vary with lab)	PRESERVATION, HOLDING TIME
Crude Oil, Diesel, Gasoline	Gasoline Range Organics (GRO)	Water	AK 101	Glass with Septa/120 ml	HCl to pH<2, Cool to 4^0C, extract and analyze in 14 days
		Soil	AK 101	4-oz Amber glass, teflon-lined septa (TLS) lid	Methanol, <25^0C, extract and analyze in 28 days
	Diesel Range Organics (DRO)	Water	AK 102	2-1L Glass Amber	pH<2 (HCl), $4^0 \pm 2^0$C, 7 days to extract, analyze <40 days
		Soil	AK 102	4-oz Amber glass, TLS lid	$4^0 \pm 2^0$C, 14 days to extract, analyze <40 days
	Residual Range Organics (RRO)	Water	No Water Method		
		Soil	AK 103	4-oz Amber glass, TLS lid	$4^0 \pm 2^0$C, 14 days to extract, analyze <40 days
	Total Polynuclear Aromatic Hydrocarbons (PAH)	Water	610	40-ml VOA, TLS lid	pH<2 (HCl) $4^0 \pm 2^0$C/14 days
		Soil	8270, 8100, or 8310	4-oz Amber glass, TLS lid	$4^0 \pm 2^0$C/14 days or per method requirements
	Total Petroleum Hydrocarbons (TPH)	Water	AK 103	Liter amber	HCl pH<2, cool to 4^0C, extract and analyze in 14 days
		Soil	AK 103	4-oz jar	$4^0 \pm 2^0$C/14 days or per method requirements
	Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX)	Water	8260M (SIM)/602	Glass with Septa/120 ml	HCl pH<2, cool to 4^0C, extract and analyze in 14 days
		Soil	8260M/ 8021B/ 8240/ AK 101	4-oz Amber glass, TLS lid	$4^0 \pm 2^0$C, extract and analyze in 14 days or per method requirements
Glycol		Water	8100M	40-ml VOA	$4^0 \pm 2^0$C/7 days or per method requirements
		Soil	8100M	4-oz jar	$4^0 \pm 2^0$C/7 days or per method requirements
Therminol		Water	8100M	40-ml VOA	$4^0 \pm 2^0$C/7 days or per method requirements
		Soil	8100M	4-oz jar	$4^0 \pm 2^0$C/7 days or per method requirements
Methanol		Water	8100M	40-ml VOA	$4^0 \pm 2^0$C/7 days or per method requirements
		Soil	8260B	4-oz jar	$4^0 \pm 2^0$C/7 days or per method requirements
Salinity		Water	SM-2520B	250-ml plastic	$4^0 \pm 2^0$C/14 days or per method requirements
		Soil	SM-2520B	4-oz jar	$4^0 \pm 2^0$C/14 days or per method requirements

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When making decisions about whether to fertilize (Tactic T-17), seed (Tactic T-21), or apply soil amendments (Tactic T-18), soil testing can provide important information. Sample site and background soils to:

- Determine nutrient deficiency (nitrogen, phosphorus, potassium),
- Determine whether pH conditions are suitable for plant growth and microbial activity, and
- Determine if salinity is suitable for germination and establishment of plants.

Collect 3 to 6 soil properties samples from a site to measure variability. For larger sites, it may be useful to collect 3 to 6 soil properties samples from the area of heaviest concentration, and 3 to 6 soil properties samples from an area of lighter concentration. In addition, always test background levels in 3 to 6 soil properties samples from a ***nearby unaffected area of the same soil and plant community.*** Such samples are essential for making good decisions.

To collect samples, use a hand-coring tool or use a shovel to dig a soil pit to collect samples representative of the entire active layer (surface to frozen subsurface). Segregate the root material/organic mat from mineral soil layer and place in large, labeled, resealable plastic bags (e.g., Ziploc brand). Ask the soils laboratory to analyze the organic soil layer separately from the mineral soil layer. Refrigerate or preferably freeze the samples until analysis to prevent biological activity. Always compare results from similar soil layers.

Testing for Nutrients

A soil nutrient test must always be accompanied by a soil pH test so that the nutrient test results can be interpreted meaningfully. If the soil pH is extremely high or low, soil nutrients will not be readily available to plants.

Nutrient Tests

NUTRIENT	TEST METHOD	POTENTIALLY DEFICIENT NUTRIENT LEVELS IN MINERAL SOIL (ppm)[1]
Nitrogen	Potassium chloride extract or 1-N potassium or sodium acetate extract	<20
Phosphorus[2]	*Alkaline Soils* (pH >7): Olsen' s extract (sodium bicarbonate)	<5
	Acidic Soils (pH <7): Bray P-1 extract	Compare with background levels
Potassium	1-N ammonium acetate extract	<20

1. To determine deficiency in *organic* soil/root mat layer, compare test results to background levels.
2. The soils laboratory must be instructed to test the soil pH in order to determine which phosphorus test method to use. Soil phosphorus is bound by calcium carbonate in alkaline soils and by iron and magnesium in acidic soils. Thus, soil testing for available nutrients must take these differences into account and use laboratory methods suited to these chemical disparities.

Testing for pH

Compare results to background levels near the site and to the normal range for North Slope tundra soil. If the pH is above or below normal range (5 to 8) in tundra, a soil amendment may be appropriate. A pH range of 6 to 7 is optimal for availability of nutrients in soil. However, other pH values may be normal for that area. If sample results are similar to background levels, soil amendments are unnecessary.

pH Tests

TEST METHOD	NORMAL pH RANGE IN NORTH SLOPE TUNDRA SOILS
1:1 soil-water paste	5 - 8

Testing for Salinity

If the site is near the coast or if a saline substance was spilled, test site and background soil salinity levels. Seeding or transplanting salt-tolerant plants may be appropriate for salt-affected sites if no salt-tolerant plants are growing nearby to revegetate the area. If the site is too saline for any plant growth, soil amendments may be appropriate.

Salinity Tests

TEST METHOD	SALINITY RANGE FOR NON-SALT-TOLERANT PLANTS	SALINITY RANGE FOR SALT-TOLERANT PLANTS
Electrical conductivity using saturated paste extract	0.3 - 4.0 mMhos/cm	4.0 - 9.0 mMhos/cm

APPLICABILITY

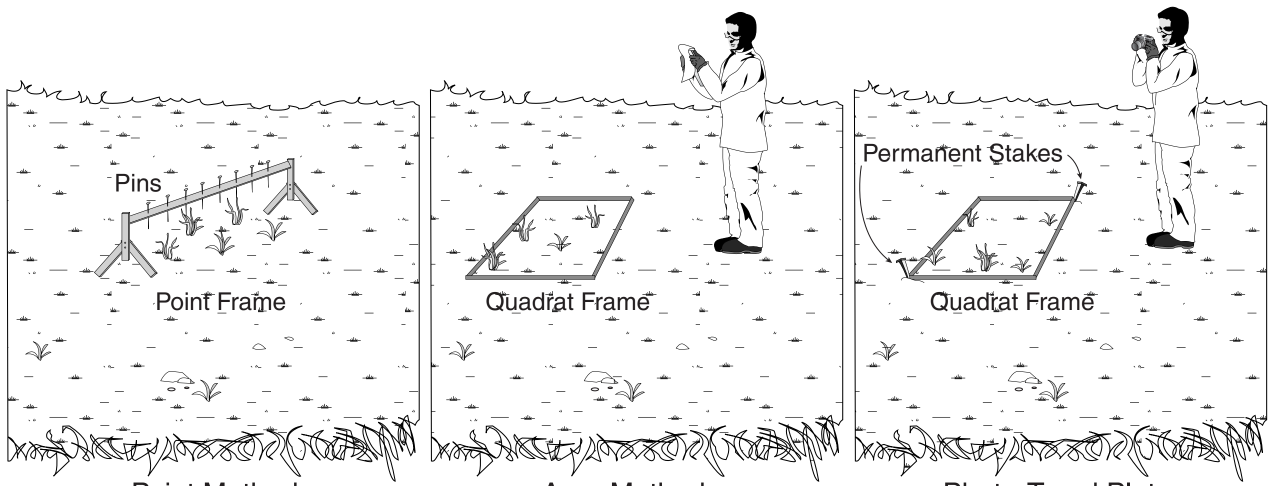
- *Spilled Substance:* All
- *Tundra Types:* All
- *Season:* Spring, summer, fall

CONSIDERATIONS AND LIMITATIONS

- Soil sampling is practicable only when the active layer is thawed.
- If more than one plant community or soil type is found on a site, additional sampling will be required.
- Comparison of results between different soil horizons and tundra types on a site is not valid. Also, samples must be compared with background results from similar soils and plant communities.

EQUIPMENT AND PERSONNEL

- Coring tool or shovel (1 worker) – to collect soil samples
- Ziploc or other plastic bags (2-gallon size) – to store samples
- Labels and notebook – Identify sample bags and soil horizons
- Cooler and blue ice – to store and ship samples to the soils laboratory



The cover, composition, and condition of tundra vegetation are measured to assess the state of the tundra before and after treatment, to monitor trends in recovery, and for comparison with adjacent non-affected areas. Long-term monitoring with photo-trend plots can document the recovery of tundra plants. Revegetation test plots can be established to determine whether plants will germinate or survive under certain circumstances and can provide important information when designing a treatment program. Identification of plants and implementing some of the monitoring techniques may require special expertise. If appropriate, consult with a plant scientist or other qualified person to develop a plan or to conduct the vegetation monitoring.

Vegetation Cover

There are two common methods to estimate vegetation cover: (1) point and (2) area methods (Bonham, 1989).

- ***Point methods*** rely on the contact of a single point, such as a pencil or a metal pin, on a plant. Either the point contacts a part of the plant or it does not. The point, or a collection of points, is used to estimate the cover in an area. Individual points are seldom used to estimate plant cover. Instead, points are collected in groups along a line or within a frame. A square-frame point method, which is popular for measuring cover of grasses and grass-like plants, uses the crosshairs of wires as guides for points. In this method, the total number of points recorded at a location divided by the number of points with vegetation "hits" represents the fraction of vegetation cover. For example, if 100 points are measured and 25 points have "hits" on plants, then the total plant cover would be 25%. Usually a number of locations are evaluated at a site and the data combined. These methods require special expertise in plant science and ecology, but point methods are the most objective way to measure cover.
- ***Area methods*** are relatively simple to implement and involve placing a quadrat (a square or circle) of known area on the ground surface and estimating the plant cover based on visual observations of the quadrat. A 20- by 50-centimeter frame is a popular quadrat size for estimating tundra vegetation cover. Usually a number of quadrats (30) are evaluated at a site to reduce the bias inherent in this method. If more than one person is estimating plant cover, the people should train together and compare estimates within the same quadrats.

Vegetation Composition

Tundra vegetation communities include a variety of vascular plants such as sedges, grasses, and other grass-like plants, forbs (broad-leaved herbs), dwarf or prostrate shrubs, mosses, liverworts, other lower plants and lichens. The diversity of plant species is a useful gauge of vegetation recovery at a site when compared to similar adjacent areas unaffected by the spill. Accurate identification of plants or lichens requires some training or special expertise in plant science. Several technical publications and flower guides can help in the identification of Alaskan tundra plants, including the following:

- Hulten, E. 1968. *Flora of Alaska and Neighboring Territories.* Stanford University Press. Stanford, CA. 100 pp. [vascular plants].
- Pratt, V.E. 1989. *Field Guide to Alaskan Wildflowers.* Alaskakrafts Publishing, Anchorage, AK. 136 pp. [vascular plants].
- Thomson, J.W. 1984. *American Arctic Lichens 1: The Macrolichens.* Columbia University Press, New York, NY. 504 pp. [lichens].
- Threlkeld, N. 1991. *Flowering Plants of the High-Arctic.* Flora Publishing, Las Cruces, NM. 37 pp. [vascular plants].
- Trelawny, J.G. *Wildflowers of the Yukon, Alaska, and Northwest Canada*. Sono Nis Press, Victoria, BC, Canada. 214 pp. [vascular plants].
- Viereck, L.A. and E.L. Little, Jr. 1986. *Alaska Trees and Shrubs.* University of Alaska Press. Fairbanks, AK. [vascular plants].
- Viereck, L.A., C.T. Dyrness, A.R. Batten, and K.J. Wenzlick. 1992. *The Alaska Vegetation Classification System.* Gen. Tech. Rep. PNW-GTR-286.U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 278 pp. [plant communities].
- Vitt, D.H., J.E. Marsh, and R.B. Bovey. 1988. *Mosses, Lichens and Ferns of Northwest North America.* Lone Pine Publishing, Edmonton, Alberta, Canada. 296 pp. [mosses and liverworts].

Condition

The condition of tundra plants growing on the site is evaluated qualitatively based on simple visual examination. Look for signs of growth, reproduction (flowers, seeds, spreading by roots) and vigor (health) using healthy vegetation not affected by the spill near the site as a reference. Signs of poor growing conditions, stress, or toxic effects may include dead plants or dead leaves, discoloration such as yellow leaves, stunted plants, lack of reproduction, and slow or no growth. Remain alert to effects of grazing, which may have removed some plant parts. Evaluation of the condition of plants does not require special expertise, although some training by experts in plant science may be useful to identify less obvious effects.

Photo-Trend Plots

Long-term monitoring with photographs of permanent plots is a popular technique for evaluating the recovery of tundra. Wooden or steel "rebar" stakes with aluminum caps can be used as markers for permanent plots. A 1-meter-square quadrat made of white PVC pipe or commercial frames is commonly used, with two stakes placed marking the opposite corners to delineate plots. Prepare a map of the plot locations so that someone else can find the plots later (Tactic AM-1). Some photo-trend plots of experimental oil spill sites on the North Slope have been documented for over 25 years, providing valuable information about the recovery of the tundra. If possible, use the same film speed and camera focal length each time a plot is documented.

Revegetation Test Plots

Before undertaking large-scale treatments such as excavation and offsite disposal (Tactic T-13), fertilizing (Tactic T-17), seeding (Tactic T-21), or transplanting (T-22), it may be desirable to determine whether seeds will germinate or transplants will survive under given conditions. Revegetation test plots can be marked and mapped using the same methods for establishing photo-trend plots, and assessed using cover, composition, and condition estimates.